BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to mining and more particularly to the hoisting of refuse materials from a mine shaft work site.

2. DESCRIPTION OF THE RELATED ART

Shaft excavation in hard rock is carried out by drilling and loading the drilled bores with explosives which are then detonated. The broken rock must then be hoisted to the surface. This is typically done with large steel buckets.

For shafts less than one and one-half kilometers deep, a standard double drum mine hoist is normally employed to hoist the shaft buckets up and to lower them down. The same hoist may later be employed for hoisting the ore from the mine, not with buckets but with rectangular-shaped conveyances called "skips". However, as the working depth of recent mines has exceeded two kilometers, the standard double drum hoist has been found to be no longer satisfactory, because it cannot handle the length of wire rope combined with the weight in the bucket.

One mining concern is known to have attempted to overcome the problem by using a multi-rope hoist known as the "Koepe" winder or friction hoist in a mine shaft with a depth of nearly two kilometers. However, this hoist was found to be unsatisfactory because the "tail ropes" had a tendency of tangling and the hoist rope was found to have a severely short life span (in some cases as little as six weeks).

Others have modified the double drum hoist by dividing each drum into two separate compartments and by winding identically sized ropes of standard diameter in each compartment. In this case, the ropes from one drum were attached to a single conveyance (skip). This type of hoist has enjoyed great commercial success and is known today as the

BMR (Blair multi-rope) hoist. The BMR hoist is in use at nearly all deep mines in two configurations, one using a mechanical coupling (double universal joint) to connect a single motor to the shafts of both hoist drums. The other makes use of an electric coupling between the single motor and the hoist drum shafts.

When a very deep shaft is to be sunk (or excavated) for a new mine it is normal practice to use a BMR hoist to remove the broken rock, since the BMR hoist can later be used when the mine is in operation to raise ore. However, during the shaft sinking stage, the BMR hoist is not fully utilized. The two ropes on each drum cannot be attached to one shaft sinking bucket, in view of the above mentioned tangling problem. In addition, in order to make the BMR hoist applicable for both shaft sinking and mine operation, the hoist motor was found to be severely over-sized for the shaft sinking phase. This meant that the motor had to run at reduced capacity (approximately one half the horsepower requirement for which it was designed. In addition, the efficiency of an over-sized electrical motor is reduced when operating at a fraction of its design rating and this resulted in a waste of about ten percent of the electrical power fed to the hoist.

Mine shafts are currently being excavated and contemplated for excavation to even greater depths (approximately 2 ½ kilometers). Therefore, there remains an urgent need for a practical device which is capable of hoisting broken rock during a shaft sinking procedure for extremely deep mine shafts, with sufficient speed and economy.

SUMMARY OF THE INVENTION

Briefly stated, the present invention provides a device for excavating a mine shaft, comprising a pair of drums, each drum having a pair of regions, each region wound with one of a pair of hoist ropes; four refuse carriers, each attached to one of the hoist ropes and drive means for driving the drums to deliver two carriers at a time to a work site in the shaft.

In another aspect of the present invention, there is provided a device for removing refuse material from a work site in a mine shaft, comprising a pair of drums, each drum having

a pair of regions, each region to engage one of a pair of hoist ropes; four carriers for carrying the refuse material, each carrier being attached to one of the hoist ropes, drive means for driving the drums, wherein the device is operable to deliver, in repetition, two groups of two carriers to the work site.

Preferably, the drive means includes at least one drive motor and a transmission arrangement for driving both of the drums and the hoist ropes on one drum are wound oppositely to the hoist ropes on the other drum. In this manner, one drum lifts two loaded refuse carriers while the other drum lowers the other two empty refuse carriers.

In one embodiment, a positioning means positions the carriers at the work site and provides four paths, each of which guides a corresponding carrier. In one example the positioning means includes four guide regions, each to receive one carrier.

The carrier may be provided by a bucket or other suitable conveyance for hoisting broken rock from the work site.

In yet another of its aspects, there is provided a method for excavating a mine shaft, comprising the steps of:

providing a pair of drums;

dividing each drum into a pair of regions;

winding each region with one of a pair of hoist ropes;

providing four refuse carriers and attaching each to one of the hoist ropes; and

driving the drums in order deliver two carriers at a time to a work site in the shaft.

Preferably, the driving step includes the step of coupling both of the drums to a single

drive motor and a transmission arrangement.

In one embodiment, the method includes the step of winding the hoist ropes on one drum opposite to the hoist ropes on the other drum, the step of positioning the carriers at the work site and the step of determining a difference in weight between the two carriers at the site. Preferably, the positioning step further includes the step of providing four guide regions, each to provide a path for one carrier.

In yet another of its aspects, the present invention provides a device for excavating a mine shaft, comprising a drum having a pair of regions, each region wound with one of a pair of hoist ropes; a pair of refuse carriers, each of which is attached to one of the hoist ropes and drive means for driving the drum to deliver the carriers to a work site in the shaft.

The present invention should significantly improve the rate of advance of sinking very deep shafts, with reduced electrical energy consumed to perform the task.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention will be provided, by way of example only, with reference to the appended drawings, in which:

Figure 1 is a plan view of a shaft excavation;

Figure 2 is a sectional view taken on line 2-2 of figure 1; and

Figure 3 is schematic view of a device for used in the excavation of figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the figures, there is provided a device 10 for removing refuse material from a work site in a mine shaft 12. The device has a pair of drums 14, 16, each of which has

a pair of regions 14a, 14b, 16a, 16b. One of four hoist ropes 18a, 18b, 20a and 20b is wound on each region. It can be seen from figure 3 that the hoist ropes on drum 14 are wound oppositely to the hoist ropes on the other drum 16.

Four carriers 30a, 30b, 32a, 32b, in this case in the form of buckets, are provided for carrying refuse material between the work site and the surface. Each bucket is attached to one of the hoist ropes.

A drive means is provided for driving the drums, wherein the device is operable to deliver, in repetition, two groups of two buckets to the work site. The drive means includes a single drive motor 34 and a transmission arrangement 34a for driving both drums. However, more than one motor may be used and the transmission may include a mechanical, electrical or other suitable transmission unit. In this case, the axles of the drums are joined by a universal joint shown at 34b, for delivering power from the motor 34 to the drum 16 via drum 14.

A positioning means shown generally at 40 positions the buckets at the work site 12. The positioning means includes a frame assembly 42 with four guide regions or wells 44 which in turn provide four paths, each for a corresponding bucket.

Figure 2 shows a shaft excavation with one arrangement for two buckets at the work site, in this case the bottom of the shaft excavation in position where the buckets may be weighed before being simultaneously hoisted to the surface.

Thus, the device 10 utilizes the unused compartment of the drums of a conventional multi-rope mine hoist by being wound with an additional wire rope, being substantially identical to the length, weight, construction and diameter of the wire rope already wound in the other compartment of each drum. The free end the wire ropes are each fitted to a shaft sinking bucket of substantially identical weight and volumetric capacity, that is within about three percent .

During operation, the drums are driven in the same direction, but because the drums are wound opposite to one another, one drum winds up its wire ropes while the other unwinds its wire ropes. With two buckets, for example buckets 30a, 30b, filled with broken rock at the work site, the motor drives the drum 16 to wind up the wire ropes 20a, 20b and thus hoist the buckets upward toward the surface. Meanwhile, the buckets 32a, 32b (empty and at the surface) are lowered as a result of the unwinding of the wire ropes 18a, 18b.

Each bucket is also provided with a guidance device (known as a cross-head) shown at 46, wherein each guidance device is of substantially identical weight and dimension. The guidance device is used to keep the shaft sinking bucket confined to its designated travel path as it rises and descends in the shaft.

When the two descending buckets reach the positioning means 40 near the shaft bottom their cross-heads are automatically detached when they abut the frame assembly 42 situated in their travel path. The two buckets are lowered further through the wells 44 to a point just beneath the frame assembly 40 called the "hanging mark". At this point, when the shaft men are ready for the buckets on the shaft bottom they "ring it down", by sending a message to the surface for the motor to be operated at reduced speed, so that the buckets can travel downward at reduced speed without guidance to a leveled area on the pile of broken rock. Here the buckets are filled with broken rock by a machine designed for that purpose and known to those skilled in the art.

When the buckets are full, a message is then conveyed to the surface and the motor is activated in reverse, causing the buckets to be hoisted to just clear the broken rock pile. Here, the wire ropes are allowed to "steady" themselves. The filled buckets maybe weighed by a device that determines the rope-end load by measuring the hydraulic pressure of compensating support devices at the sheave wheel atop the head frame, or by other means such as a simple level made from a clear plastic hose filled with water. In this latter case, if the filled buckets hang to the same level, normally they are of equal weight. Once the shaft men are suitably trained, they may be able to judge, by eye, when the buckets have substantially the same weight, to make measurement otherwise unnecessary.

Generally, the weights of the filled buckets should be within ½ tonne (500 kilograms) of one another. If not, broken rock is removed from the heavier bucket or added to the lighter bucket before both are hoisted simultaneously to surface.

A weighing system that can determine that the rope-end loads are nearly equal is desirable, in some cases, to ensure that the buckets reach the dump position on surface simultaneously. This is due to the fact that the wire ropes stretch under load. As a consequence, if the loading is not equal the buckets will reach surface one ahead of the other. To determine the allowable out of balance load the following formula may be used:

$$e = FL/EA$$

where e is the difference in elevation of the buckets when they have reached the surface dump in the head frame, F is the rope-end load in Kilonewtons (kn.), L is the length of wire rope between the surface dump and the shaft bottom in meters, E is the modulus of elasticity of the roper in Gigapascals (GPa) and A is the area of circle enclosing the wire rope section in square millimeters.

Thus for a difference in "end load" (weight of the bucket and its payload) of 500 kg, will produce a force of 4.9 kn at the rope-end. With a length of 2.600 kilometers; a modulus of 65 GPa; and a rope diameter of 51 millimeters, this weight difference will produce a differential rope stretch of 0.096 meters.

Thus, device 10 provides a method for hoisting or elevating shot (or broken) rock more efficiently during the excavation of a deep mine shaft. This is done by simultaneously hoisting two shaft sinking buckets (or other conveyances) toward the surface of the shaft, while two others are lowered into the shaft. This allows the full capacity of a multi-rope double drum winder (such as a BMR hoist, for example) to be utilized for shaft sinking. Moreover, it increases the efficiency of the electrical motors driving the BMR hoist since it may be run at near its design capacity.

While the above device makes use of a pair of drums, each coupled with a pair of buckets, there may be some cases where a single drum can be used instead of two. In this case, the single drum would have a pair of regions, each region wound with one of a pair of hoist ropes. Each of a pair of refuse carrier may then be attached to one of the hoist ropes and drive means can be provided for driving the single drum to deliver the carriers to a work site in the shaft.